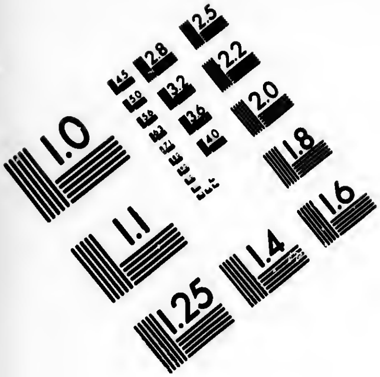

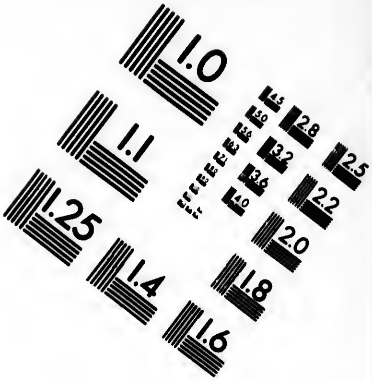

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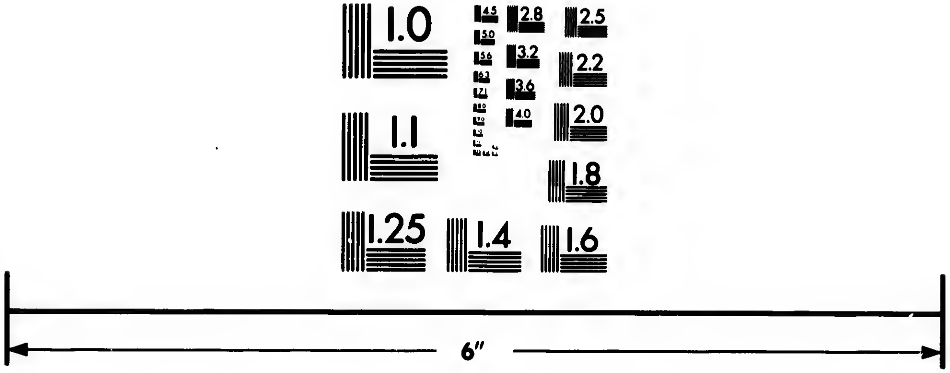

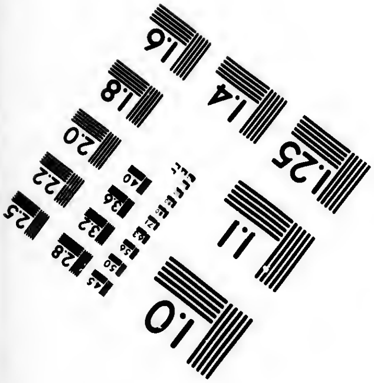

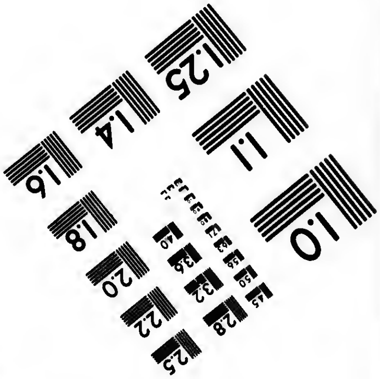

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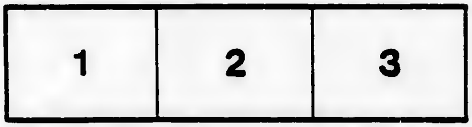

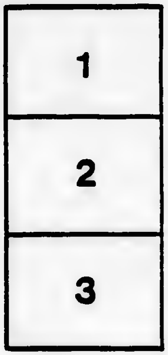

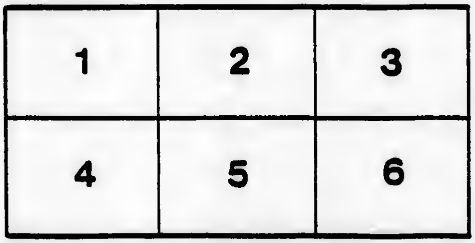

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ON SOME CANADIAN ROCKS CONTAINING SCAPOLITE, WITH A FEW NOTES ON SOME ROCKS ASSOCIATED WITH THE APATITE DEPOSITS.

By FRANK D. ADAMS, of the Canadian Geological Survey, and ANDREW C. LAWSON, Ph. D., of the Canadian Geological Survey.

At the meeting of the British Association for the Advancement of Science, held in Montreal in the summer of 1884, a short paper entitled "On the Occurrence of the Norwegian 'Apatitbringer' in Canada, with a Few Notes on the Microscopic Characters of some Laurentian Amphibolites," was read before the Geological Section by Mr. Frank D. Adams. Only a short extract of some dozen lines was prepared for the Transactions, as it was proposed to continue the investigation of these rocks and especially to study their geological relations in the field. A thorough geological examination of the district from which these rocks were obtained has not, however, been found to be practicable, and in the following paper it is proposed to give a more detailed description of them, together with the results of the examination of a few others collected since that time.

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The peculiar scapolite rock, referred to above as the "Apatitbringer," was first mentioned by Brögger and Reusch in a paper entitled "Vorkommen des Apatit in Norwegen."[1] In this paper, the authors state that at Oedegarden in Bamle (Southern Norway), where the largest apatite deposits of that country are found,—some idea of the extent of these deposits may be obtained from the fact that in 1882, at Oedegarden alone, 15,000 tons of apatite were mined, between 700 and 800 men being employed—the mineral occurs in, or in the immediate vicinity of, a rock described by them as "Geflecter Gabbro." This rock, however, differed from gabbro, as that word is generally understood, as it was stated to be composed essentially of amphibole and labradorite, and it has been shown to be a peculiar form assumed by the normal gabbro of the country on approaching the apatite veins. Referring to this work, Kjerulf, in his "Geologie des südlichen und mittleren Norwegen," after mentioning one variety of gabbro as an "Erzbringer," says:—"Der bunte oder Hornblende Gabbro......wegen seiner Rolle als 'Apatitbringer' gekannt zu sein verdient." It was also described as Hornblende Gabbro in a paper by H. Möhl.[2] Michel Lévy,[3] who subsequently examined the work, showed that, as conjectured by Lang,[4] the white mineral was really not plagioclase, but a mineral of the scapolite family, which he referred to the species wernerite. Sjögren,[5] who has more recently carefully examined the rock, refers the mineral to the species dipyr, calling the rock a dipyr diorite.

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[1] Zeit. d. deutsch. geol., Gesellsch, 1875, Heft III.

[2] Die Eruptivgesteine Norwegens, mikroskopisch untersucht und beschrieben. Nyt magazin for Naturwidenskaberne. Bd. XXIII.

[3] Sur une roche à sphene, amphibole et wernerite granulitique de Bamle (Norwège). Bull. Soc. Min. France. No. 3. 1878.

Sur le gisement de l'amphibolite à wernerite granulitique d'Oedegaard pres Bamle (Norwège). Bull. Soc. Min. France. No. 5. 1878.

[4] E'in Beitag zur Kenutniss norwegischer Gabbros, Z D. G. G. 1879. XXXI. 484.

[5] Om de norska apatitforekomsterna, etc. Geol. Fören i, Stock. Förh. 1883. 447.

It is believed by those who have studied the rock and its relations in the field, to be derived from the alteration of the true gabbro adjoining it, the pyroxene of the gabbro being altered to hornblende and the plagioclase of the gabbro to scapolite. The change would be essentially one of diagenesis. Intermediate varieties are found containing diallage "rests" in the hornblende and plagioclase mixed with scapolite.[1] In this connection, an observation made by Fouqué and Michel Lévy[2] is especially interesting, namely, that when the rock is fused and allowed to cool, the magma recrystallizes as a mixture of labradorite and augite.

The occurrence of scapolite in certain of the crystalline schists, especially augite gneiss and amphibolite, has been mentioned by Törnebohm[3], Dathe[4], Becke[5], Wulf,[6] Mügge,[7] Svedmark,[8] and others. The last-named author, in addition to a number of scapolite-bearing gneisses and amphibolites, describes an amphibolite from Orebro which contains scapolite to the exclusion of plagioclase, and which also holds a little diallage and mica. In composition, therefore, it would be closely allied to the Oedegarden rock.

Lacroix and Baret[1] have also recently described a pyroxene wernerite rock which occurs associated with gneiss

[1] See Sjögren, loc. cit., and Rosenbusch, Mass. Gest. I., 165.

[2] Sur la transformation par voie ignée, etc. Bull. Soc. Min. France. 1879. 105.

[3] Ett par Skapolitförande Bergarter. Geol. Fören. i. Stöck. Förh. 1882. VI. 192.

[4] Jahr. preuss. geol. Landesanstalt. 1884. LXXVI.

[5] Die Gneissformation des niederösterr. Waldviertels. T. M. P. M. 1882. 369.

[6] Beitrag zur Petrographie des Hererolandes in Südwest-Africa, T. M. P. M. 1887. 213.

[7] Ueber einige Gesteine des Massai-Landes. N. J. Beil. Band. IV. Heft III.

[8] Om nagra Svenska Skapolitförande bergarter. Geol. Fören. i. Stock. Förh. VII. 1884. 293.

and amphibolite at Point-du-Jour, near St. Nazaire, in France. In this rock the pyroxene is associated with, and sometimes completely replaced by, a very pleochroic amphibole, and in some specimens the wernerite is associated with oligoclase, the rock thus passing into a wernerite oligoclase amphibolite.

A most interesting paper in this connection and one which will be referred to again, was published by Dr. A. P. Coleman in the Transactions of the Royal Society of Canada for 1887.[2]

As Canada is the only country, except Norway, in which apatite is extensively mined, and as in most respects the character and mode of occurrence of the mineral in both countries are very similar, a corresponding relation to dipyrdiorite might be looked for. In Canada, however, as pointed out by Dr. Harrington in his excellent "Report on the Minerals of some of the Apatite-bearing Veins of Ottawa County, Que.[1]," this relation does not exist, the important deposits of apatite occurring associated with a granular pyroxene rock, which is always regarded by prospectors as indicative of the presence of apatite, and occupies, in that way, to a certain extent, the position of the "Apatitbringer" in Norway. "These[2] pyroxene rocks, which have been called by Hunt pyroxenites, vary considerably in their characters. Sometimes they consist almost exclusively of pyroxene, though more commonly quartz and orthoclase are present. Mica, too, is of frequent occurrence, while minute garnets may occasionally be seen. The frequent presence of disseminated grains of apatite is also an important fact. When pyroxene is the principal mineral, the rock commonly shows little or no trace of bedding, but is often a good deal jointed. Its aspect, when the pyroxene is of a dark colour, is often that of a massive eruptive rock." It is very intimately associated with the apatite, in some places apparently passing imperceptibly into it.

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[1] Lacroix et Baret.—Sur la pyroxénite à wernérite du Point-du-Jour près Saint-Nazaire. Bull. Soc. Min. France, July, 1887.

Lacroix, A.—Note sur une roche à wernérite granulitique des environs de Saint-Nazaire. C. R. CIV. 1011.

[2] Microscopic Petrography of the Drift of Central Ontario.

[1] Reports of Progress of the Geological Survey of Canada, 1877-8.

[2] Ibid.

In order to ascertain whether these pyroxenites contained any scapolite, two specimens—one from lots 35 and 36, range V. of Portland West, and the other from the well-known McLaurin Mine in Templeton—were sliced and examined microscopically. They are both rather coarse-grained, that from Portland being of a light greyish colour and holding a little disseminated apatite, sphene and pyrite, while the Templeton rock is light green in colour, and in certain places contains a good deal of biotite. Neither of them contained any scapolite, nor could any be found in the wall rock of the Emerald Mine in the township of Buckingham.

Mr. Coste, Mining Engineer to the Geological Survey of Canada, who has had occasion to visit a number of the apatite mines, considers that the apatite occurs in the form of more or less irregular veins, the above mentioned pyroxene rocks occupying the position of vein stones. He also believes that these veins of apatite and pyroxenite are found almost invariably in connection with a certain eruptive rock, which varies much in texture but is generally rather coarse-grained, and which is composed largely of orthoclase generally having a bluish or lilac tint. Two specimens of this rock, collected by Mr. Coste,—one from the "Star Hill Mine," range VIII., Portland West, in the Province of Quebec, and the other from the "Blessington Mine," lots 29 and 30, range I., Inchinbrooke, in the Province of Ontario,—were also sliced and examined. The two rocks resemble one another in appearance, that from the "Blessington Mine," however, being somewhat darker in colour.

Under the microscope, the "Star Hill" rock is seen to be composed essentially of orthoclase and biotite, with very small amounts of magnetite and pyrite. The orthoclase is almost always clear and fresh; the biotite is also very fresh, although in places it is slightly decomposed to chlorite. The magnetite is probably titaniferous, as occasionally it is altered to leucoxene. Another hand specimen of the same rock was found to contain, in addition to the minerals mentioned above, a little quartz and a little plr gioclase, and the orthoclase contained the peculiar intergrowths characteristic of perthite. This specimen had a very obscure foliation, and the quartz and orthoclase showed evidence of having been submitted to pressure. It also contained a few forms of some mineral which had been entirely decomposed, but which may have been pyroxene.

The rock from the "Blessington Mine" is composed essentially of orthoclase, biotite, pyroxene and magnetite, with a little plagioclase, hornblende, pyrite, calcite and apatite. The orthoclase contains a multitude of minute, black, rod-like inclusions and fine dust. The pyroxene occurs in large amount, and is more plentiful than the biotite. It is pale green in colour, with scarcely noticeable pleochroism and large angle of extinction. It is generally without good crystalline form, but occasionally occurs in rude crystals. It is also occasionally twinned. The hornblende occurs in very small amount—intergrown with the pyroxene and biotite. The calcite is present in small amount, and results from the decomposition of the pyroxene and feldspar. The magnetite may be titaniferous. The apatite is uniaxial and negative, and occurs in irregular shaped grains, with high index of retraction and faint bluish colour, generally associated with the pyroxene.

The rock from the "Star Hill Mine" is therefore a *mica syenite,* and that from the "Blessington Mine" an *augite mica syenite.* It will be a matter of interest to ascertain whether these rocks occupy a similar relation to the apatite at the other mines. A monograph of the apatite district of the Province of Quebec, which is now being prepared by Mr. Ingall of the Geological Survey, willl decide this and many other important points.

Among a series of specimens from the vicinity of the town of Arnprior, on the River Ottawa, which were some time ago, sent to Mr. Hoffmann of this Survey for examination, there was, however, one small specimen which exactly resembled the Oedegarden rock, and which, when sliced and examined with the microscope, proved to be identical with it. Unfortunately, we were unable to obtain any further specimens or to ascertain the locality from which it came more precisely than that, as above mentioned, it was from near the town of Arnprior. The large collection of rocks in the museum of the Geological Survey of Canada was then carefully examined, and sections were prepared of all those which at all resembled this rock in appearance. An examination of these sections resulted in the discovery of three other specimens, from widely separated localities, rich in scapolite, but unlike the Arnprior rock, containing also a considerable proportion of plagioclase.

The first of these specimens was collected by the late Mr. Vennor at Mazinaw Lake, in the township of Abinger, in the county of Addington; the second was obtained by Mr. Coste at the Robertsville or Mississippi Iron Mine, on lot 3, range VIII. of the township of Palmerstone, in the county of Frontenac, and the third was collected by Dr. Bell from lot 28, range I. of McDougall, in the Parry Sound district. All three rocks are of Laurentian age, and come from that great stretch of Laurentian country lying north of Lake Ontario and south of of Lake Nipissing and the River Ottawa. The eastern half of this area was examined by Mr. Vennor, and found by him to be rich in amphibolites, dioritic schists and diorites; a very common, coarse-grained variety of the latter being called by him "blotched diorite," and it is associated with these dioritic rocks, whose occurrence at Mazinaw Lake is mentioned by Mr. Vennor, that the Arnprior and Mazinaw Lake rocks apparently occur. The rock from the Robertsville Mine is found associated with crystalline limestone and granite. In some places it forms the wall rock of the magnetite, between 50,000 and 60,000 tons of which have been mined. The mode of occurrence of the McDougall rock is described by Dr. Bell in the following extracts from his report on the country north of Lake Huron and east of Lake Superior.[1]

"Eastward of the village of Parry Sound, along the road of the same name, dark, hornblendic gneiss or schist prevails for a distance of about a mile and a half. A band of crystalline limestone, and one of mottled white and black diorite, occur in association with these rocks where this road crosses lot 28, concession I., township of McDougall." "The rock which is here immediately associated with the limestone is a remarkable looking diorite, consisting of a white ground, thickly mottled with patches of dark-green or blackish hornblende, having their longer diameters arranged parallel to the general bedding. This appears to be the rock which Mr. Vennor has described in the Hastings, Lanark and Renfrew region, under the name of 'blotched diorite." The rock from near Arnprior is rather coarse-grained, and with the naked eye is seen to consist of white of bluish-white scapolite, with a rather larger amount of what looks like a dark greenish hornblende. In appearance, the scapolite closely resembles that occurring in the Norwegian rock, which has been aptly compared by Brögger to wet snow. The rock appears to have an indistinct foliation, but the specimen sent was too small to show its structure distinctly. When thin sections are examined with the microscope, the rock is seen to be fresh and almost entirely free from decomposition products. The structure is for the most part granular, none of the minerals being idiomorphic.[2] The principal constituents are found to be pyroxene, hornblende and scapolite; and the accessory ones epidote, enstatite, pyrrhotite and rutile.

The pyroxene is very light in colour and faintly pleochroic. $\mathfrak{A}$=yellowish; $\mathfrak{B}$=greenish; $\mathfrak{C}$=light green. The absorption is $\mathfrak{C} > \mathfrak{B} > \mathfrak{A}$. Basal sections show well-marked prismatic cleavages intersecting at an angle of about 90°;

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[1] Reports of Progress of Geological Survey of Canada, 1876-77, pp. 199 and 204.

Rosenbusch.—Mikroskopische Physiographie der massigen Gersteine. Band II. i. Abtheilung,—1886.

while in sections parallel to the clinopinnacoid, the extinction is seen to be about 39° or 40° against C. Most of the pyroxene has a peculiar, fibrous or mottled appearance, due to what is apparently its partial alteration into a light green pleochroic hornblende. This hornblende is darker in colour and generally has a shred-like character at its contact with the pyroxene, the two minerals, however, often having a sharp line of contact, which in this case is usually a cleavage trace. The various patches, streaks or shreds of hornblende scattered through an individual of pyroxene generally have a common orientation, presenting elongated forms in prismatic sections of the pyroxene, but on basal sections generally appearing as irregular spots, the hornblende strings being inlaid parallel to the C axis of the pyroxene, and sometimes also elongated parallel to $\infty P \infty$, both minerals having the B axis in common.

In addition to the hornblende associated with the pyroxene, the rock contains other hornblende which shows no evidence of derivation from pyroxene. This is of a deep green colour, has the usual perfect cleavages, and occurs scattered through the rock in irregular shaped masses, which however occasionally have well defined prismatic contours. The pleochroism is strongly marked $\mathfrak{C}$=dark bluish-green; $\mathfrak{B}$=dark green; $\mathfrak{A}$=light yellowish or brownish-green.

The scapolite is abundant, and occurs in large, colourless grains. In basal sections a very distinct uniaxial figure was repeatedly obtained, and by means of the quarter-undulation plate its negative character was clearly established. The quadratic cleavage parallel to $\infty P \infty$ is distinct. The polarization colours are either brilliant or are of a pale bluish-gray tint like those of the feldspars. The brilliantly polarizing scapolite occurs side by side with that which shows the soft gray tints, so that the difference does not seem to be due to a varying thickness of the section. In two instances, traces of polysynthetic lamellæ were observed, in which the extinction, though much less distinct than in plagioclase, resembled it otherwise very

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strongly. The appearance was very suggestive of the derivation of the scapolite from plagioclase, and if this be the case the twinning structure of the latter is retained after the mineral has apparently been entirely changed to scapolite. Probably, however, in these cases the change may not be complete, and although the mineral has the characters of scapolite, there may be sufficient plagioclase remaining in twinning position to cause the alternate oblique extinction observed. There are in the scapolite, inclusions of a dusty, opaque character, besides fluid inclusions and microlites. The dust and fluid exclusions are disposed either in planes or irregularly; in the latter case, the section may be really parallel to the planes in which the inclusions lie. The microlites lie for the most part in cleavage lines, and have their long axes either perpendicular or oblique to certain planes (sometimes cracks) which cross the cleavages. In some instances, numerous opaque, thick plates and stout rods were observed lying parallel to the cleavage lines. When seen on edge, these plates and rods had rectangular outlines, although rounded patches of the same opaque material could sometimes be seen. Occasionally the scapolite is somewhat cloudy, owing to the presence of a kaolin-like decomposition product, but generally it is quite fresh and clear. The epidote occurs in small, nearly colourless grains of irregular shape. Scattered through both the hornblende and the pyroxene, and occasionally to be observed in larger grains situated between those of the other constituents, there are irregularly rounded or oval grains of a mineral which is referred to the rhombic pyroxenes. It is biaxial, possesses a rather high index of retraction, and polarizes in brilliant though somewhat subdued tints. It has one well-marked cleavage, to which the extinction is parallel, and has a fine, fibrous structure, also parallel to the cleavage, which seems to be due to decomposition. The mineral is not quite colourless, but has a faint purplish or amythestine tint, and occasionally seems to be slightly pleochroic. Pyrrhotite occurs very sparingly, and is distinguished by its opacity and its bronze colour in reflected light. In one instance it was seen to be included in the scapolite, which was stained yellowish-green in the vicinity of the grain. Other grains occur bedded in the hornblende. Rutile occurs in occasional grains, rather large in size and irregular in shape, but has not been observed in its usual prismatic habit. It has a high index of retraction and a faint brownish or reddish colour, and resembles titanite very much both in ordinary light and between crossed Nichols. In convergent light, however, it gives a distinct uniaxial interference figure, and there are traces of a quadratic cleavage. It polarizes in dull, leaden-gray tints. In two instances these grains of rutile were seen to be made up of lamellæ, as if polysynthetically twinned. There was, however, no alternation of extinction corresponding to the alternate lamellæ. In a certain position between crossed Nichols, the section was broken up into these lamellæ, which were alternately light and dark. On revolving the stage through 90°, the same appearance is produced, *i.e.*, the same lamellæ are light and dark as before, and there is no position in which the light lamellæ become dark and the dark lamellæ light. In one of these two instances, the polyxenthetic lamellæ appeared to cross each other, the angle between the two sets being, as nearly as could be measured, 53°. The rutile is associated with the scapolite, and in the last-mentioned case, where the grain has a diameter of 1·4 mm., it is entirely surrounded by scapolite. In this case the glass cover having been removed, the section was treated with hydrochloric acid, the mineral, however, was quite unacted upon. Following Sjögren, the rock may be termed a *Scapolite Diorite.*

The rock from Mazinaw Lake [Museum Number 2930] is rather coarse-grained and distinctly foliated. The principal constituents are hornblende, biotite, scapolite, plagioclase and, in smaller amount, quartz. The accessory minerals are epidote, ziosite and titanite. Pyroxene does not occur in any of the slides. In nearly all the sections the rock is seen to be made up of two parts: (1) a fine-grained, granulitic "groundmass" composed chiefly of feldspar with some quartz, biotite and hornblende; and (2) a coarser grained portion imbedded in this "groundmass," but not having any definite crystalline boundaries. The minerals composing this coarser grained portion are scapolite, plagioclase, biotite, hornblende, and occasionally quartz. A gradation between the "groundmass" and the coarser constituents can generally be observed, and in some few nstances there appears to be evidence that the former was derived from the latter, particularly from the plagioclase, by crushing, the structure being cataclastic. In this connection, the absence of pyroxene is noteworthy. The scapolite is generally coarsely crystalline, and present in large amount. Only occasionally is it sparing in quantity or finely crystalline. Very commonly it occurs in large plates of uniform orientation, in which more or less elongated individuals of hornblende or biotite lie irregularly imbedded, the structure being quite analogous in appearance to the ophitic structure seen in diabases. In one case, a large plate of scapolite was observed to inclose an irregular grain of plagioclase, the latter being somewhat decomposed. The scapolite usually occurs side by side with plagioclase or with plagioclase and quartz, all being in very irregular shaped grains, evidently allotriomorphic. The line of contact between the plagioclase and scapolite is quite sharp, and generally there is but little evidence of the derivation of the latter from the former. Associated with the scapolite, there is often a fine-grained aggregate of gray decomposition products, which shows aggregate polarization in brilliant but subdued colours, and which probably consists of muscovite, calcite, etc.

Hornblende and biotite are well represented in all the sections, the former being rather more abundant than the latter. The hornblende is of a deep green colour, strongly pleochroic, and contains numerous inclusions. The biotite is of the usual brown colour, and some grains contain inclusions, in the shape of films running in between the cleavage lamellæ, of a mineral which between crossed Nichols resembles scapolite, but which are so minute that their character cannot be determined with certainty. The plagioclase is usually quite fresh and clear. In the "groundmass," the feldspars are only twinned occasionally and can be distinguished from the quartz only by means of the interference figure in convergent polarized light.

The most striking of the accessory minerals, and at the same time the only constantly idiomorphic constituent of the rock, is the epidote. It occurs in elongated prisms of rhombic cross-section, which vary much in width, in some cases forming slender needles, but elsewhere being of stout columnar habit. The crystals are colourless, but between crossed Nichols, polarize in the usual brilliant manner. The extinction is parallel to the side of the prism that is to the axis, and in cross-sections is oblique to both of the crystallographic lines. The plane of the optic axes may readily be determined to be perpendicular to B. The index of retraction is high, the prisms standing out in marked relief, and irregular transverse partings can occasionally be observed. In one section a large plate of zoisite was observed. It was oblong in shape, showed a perfect cleavage parallel to its length $(\infty P \breve{\infty})$, and a distinct cross parting. The plane of the optic axes was found to be at right angles to the C axis. The mineral is colourless, and shows dull gray to deep blue polarization colours. Titanite is rare, and occurs in small, rudely wedge-shaped grains. The rock may be called a *Plagioclase Scapolite Amphibolite.*

The rock from McDougall [Museum Number, 2996,] is coarse-grained, and possesses a rather indistinct foliation. Under the microscope, it is seen to be a granular aggregate of plagioclase, scapolite and green hornblende, with a sparing amount of pyroxene and quartz and a little accessory epidote and pyrite. The plagioclase is for the most part fresh, though occasionally a little cloudy, and by means of Lévy and Pumpelly's method was found to belong to the anorthite-labradorite end of the plagioclase series. The plagioclase and hornblende are present in about equal proportions. The scapolite is less abundant, and occurs in large, irregular-shaped plates, usually somewhat cloudy from the presence of decomposition products. The pyroxene is present in rather sparing amount, and is not seen in every slide. It is pale green in colour and without noticeable pleochroism, and is intimately associated wtth the hornblende, being in many cases apparently in process of alteration into that mineral, as in the case of the Arnprior rock. It may, perhaps, best be termed a *Plagioclase Scapolite Diorite.*

The rock from the Robertsville Mine is rather coarse-grained, and in external appearance bears a strong resemblance to that from McDougall, but possesses a more distinct foliation. Under the microscope it is seen to be composed of scapolite, plagioclase and hornblende, with accessory biotite and epidote. The scapolite is present in large amount, and is generally very free from decomposition products. It usually occurs in rather large plates, which polarize in brilliant colours. The cleavage with extinction parallel to it is well seen, and in sections parallel to the base the mineral is found to be uniaxial and negative. The plagioclase, which is also present in large amount, polarizes in much more subdued tones. Polysyntheti twinning is seen in many, but not in all cases. It is often rendered cloudy by the presence of decomposition products, which resemble kaolin in appearance, and as a general rule is not so fresh as the scapolite which occurs side by side with it. The hornblende, which is light green in colour, is without good crystalline form, but is not fibrous in character. It is strongly pleochroic, in yellowish and bluish-green tints. The biotite occurs in very small amount, intimately associated with the hornblende and partly altered to chlorite. Scattered through the plagio clase, and less frequently also in the scapolite, are many small, stout prisms and irregular grains of a colourless mineral, with high index of retraction, and which polarizes in brilliant colours. Occasionally these are pleochroic, with the yellowish tint characteristic of epidote, and have been referred to that species. The rock, which under the microscope resembles one of the crystalline schists, may be termed a *Plagioclase Scapolite Amphibolite.*

Although these scapolite rocks have been ascertained to exist at only four localities, they probably occur abundantly in various parts of the district from which these were obtained, and it is very interesting to note that in his study of the Petrography of the Drift of Central Ontario,—his materials being collected principally about Cobourg, situated about the middle of the southern limit of this same district,—Dr. Coleman found several specimens of "scapolite-diorite schist," which, judging from his description, must be identical in character with the rocks described in this paper.

Although the derivation of at least a part of the hornblende of these rocks from pyroxene is well nigh certain, the derivation of the scapolite from plagioclase, which, as before stated, has been pretty clearly proved in the case of the Norwegian rock, is not so evident in these similar rocks from Canada. There is certainly nothing in the sections fatal to this supposition, and several facts mentioned in this description of the slides seem to give some support to it. A much more exhaustive study of the rocks in their relations to the pyroxenic and dioritic rocks of the district would, however, be required to decide the question, and such an investigation would probably throw additional light on the curious paramorphism which the constituents of some rocks undergo, apparently under changed conditions of pressure. Fouqué's experiment, referred to above, on the minerals resulting from prism of the Norwegian rock, is of especial interest in this connection, as tending to show that hornblende and scapolite are not stable forms at high temperatures, at least under the ordinary pressure. The whole question is one of much interest, and one which, of late, has attracted a good deal of attention.[1]

As mentioned above, the rocks from McDougall and Palmerstone occur associated with crystalline limestones

[1] See Williams on The Gabbros and Associated Hornblende Rocks occurring in the neighbourhood of Baltimore, Md., p. 49. Bull. U. S. Geological Survey, No. 28.

of the Laurentian System. There are, however, many amphibolites and dioritic rocks occurring in the same district intimately associated with these limestones, but which contain no scapolite whatever. There is, for example, a great thickness of amphibolites, interstratified with crystalline limestone, exposed on the north shore of the Ottawa, just below the town of Arnprior, which we examined some years ago when on a visit to that locality for the purpose of endeavouring to discover the Scapolite-Diorite in place. They are all rather fine-grained and weather dark gray and black, and have a more or less distinct foliation. They were followed for a distance of about five miles below Arnprior, being gradually replaced by quartz feldspar rocks. Like all the other amphibolites and dioritic rocks of the district which do not hold scapolite, when examined with the naked eye the feldspar is seen to be wanting in that peculiar bluish-white tint characteristic of the scapolite, and which the Norwegian geologists compared to wet snow. Three specimens, collected respectively a quarter of a mile, two and a quarter, and three and a half miles below Arnprior, were sliced and examined. The last of these is traversed by little pegmatite veins, and under the microscope is found to be composed of hornblende, biotite and plagioclase, with accessories of epidote and sphene. The hornblende is green in colour, strongly pleochroic and without any tendency to a fibrous structure. It occurs in irregular shaped fragments, which occasionally have an imperfect idiomorphic development, and which mark the lines of foliation. The biotite, which is present in much smaller amount than the hornblende, is brown, with the usual strong dichroism and parallel extinction. The plagioclase is generally twinned, the lamellæ being narrow and the twinning generally faint. All untwinned grains which could be found cut in a direction at right angles to an optic axis, showed the revolving bar of a biaxial crystal. They polarize in rather dull tints, and extinguish simultaneously over the whole surface, showing little or no evidence of having been submitted to pressure.

The pyrite, epidote and sphene occur in small amount in little irregular shaped grains.

The other two specimens contain no biotite, but hold a certain amount of quartz, recognized by the absence of cleavage and decomposition products and by its uniaxial and positive character. The quartz grains are sometimes broken, but do not show much evidence of pressure either. The specimen collected about a quarter of a mile below Arnprior contains a considerable amount of quartz, while that from two and a quarter miles below, holds less quartz, and contains, in addition to the pyrite, a little magnetite or ilmenite.

To sum up, therefore, it may be said:—

(1) That the Scapolite Diorite, which in Norway occurs so intimately associated with the apatite deposits, does not occupy the same relation to the Canadian deposits.

(2) That its place in Canada is taken by certain pyroxenic rocks which have not, as yet, been thoroughly studied.

(3) That Scapolite Diorite and transition rocks between it and gabbro, identical with the Norwegian rocks, do occur in our Laurentian System, associated with amphibolites and crystalline limestones.